



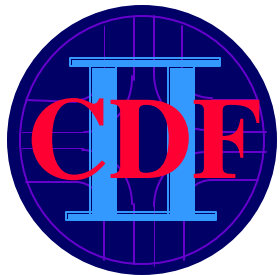
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# Electroweak Physics Prospects for CDF in Run II

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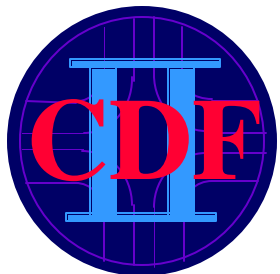
CDF Collaboration



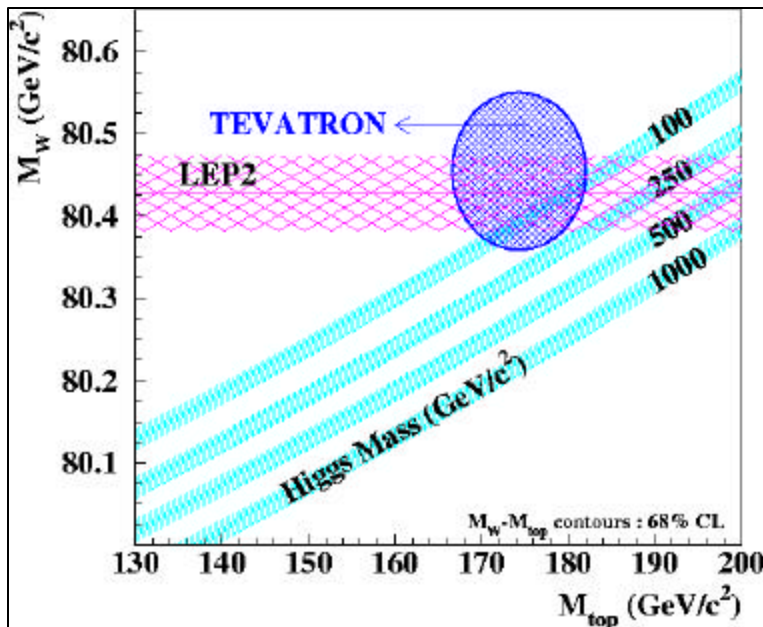
## Run II EWK Physics Goals

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- Precision measurements of Standard Model electroweak parameters
  - $M_W$ ,  $M_{\text{top}}$ ,  $\Gamma_W$ , and  $\sin^2\theta_W^{\text{eff}}$  indirectly constrain  $M_h$  within the Standard Model framework and are sensitive to new physics above the EWK scale.
- Precision tests of Standard Model Predictions
  - Measurements of W and Z production cross sections and W charge asymmetry test QCD.
  - Diboson production cross sections measurements probe EWK couplings and are also sensitive to new physics.



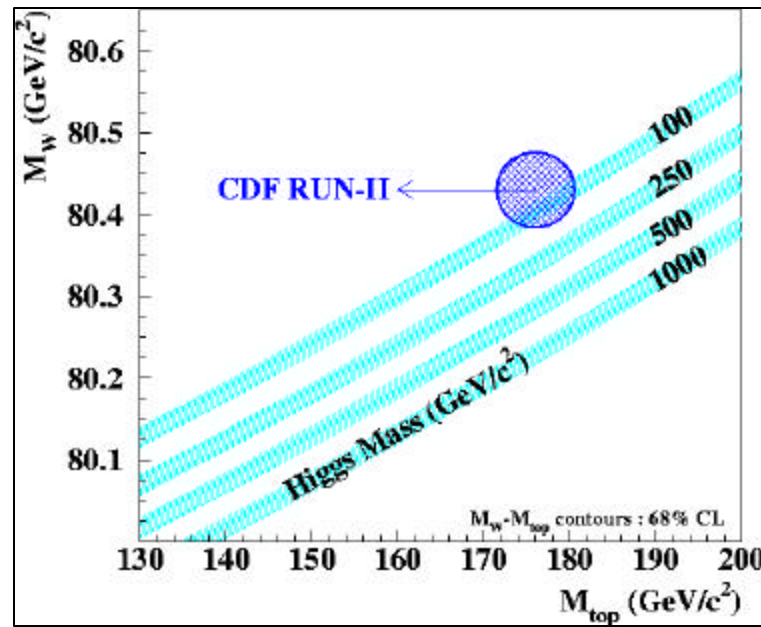
# Indirect Higgs Searches



Run I :

$$M_W = 80.456 \pm 0.059 \text{ GeV}/c^2$$

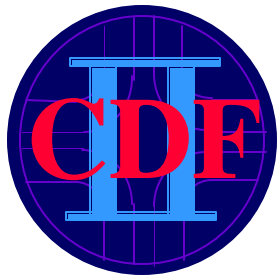
$$M_{\text{top}} = 174.3 \pm 5.1 \text{ GeV}/c^2$$



Run II ( $2 \text{ fb}^{-1}$ ):

$$M_W = \pm 0.040 \text{ GeV}/c^2$$

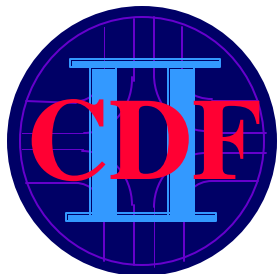
$$M_{\text{top}} = \pm 2\text{-}3 \text{ GeV}/c^2$$



## W, Z Production Cross Sections

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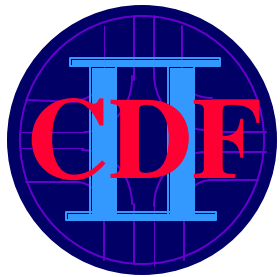
- Run II (2002)
  - $\sqrt{s} = 1.96 \text{ TeV}$
  - $\int \mathcal{L} \cdot dt = 10.1 \text{ pb}^{-1}$
- $\sigma \cdot B = (N_{\text{obs}} - N_{\text{bg}}) / A \cdot \epsilon \int \mathcal{L} \cdot dt$ 
  - $N_{\text{obs}}$  = Number of events observed
  - $N_{\text{bg}}$  = Estimated number of background events
  - $A$  = Kinematic and geometrical acceptance
  - $\epsilon$  = Total efficiency
  - $\int \mathcal{L} \cdot dt$  = Integrated luminosity



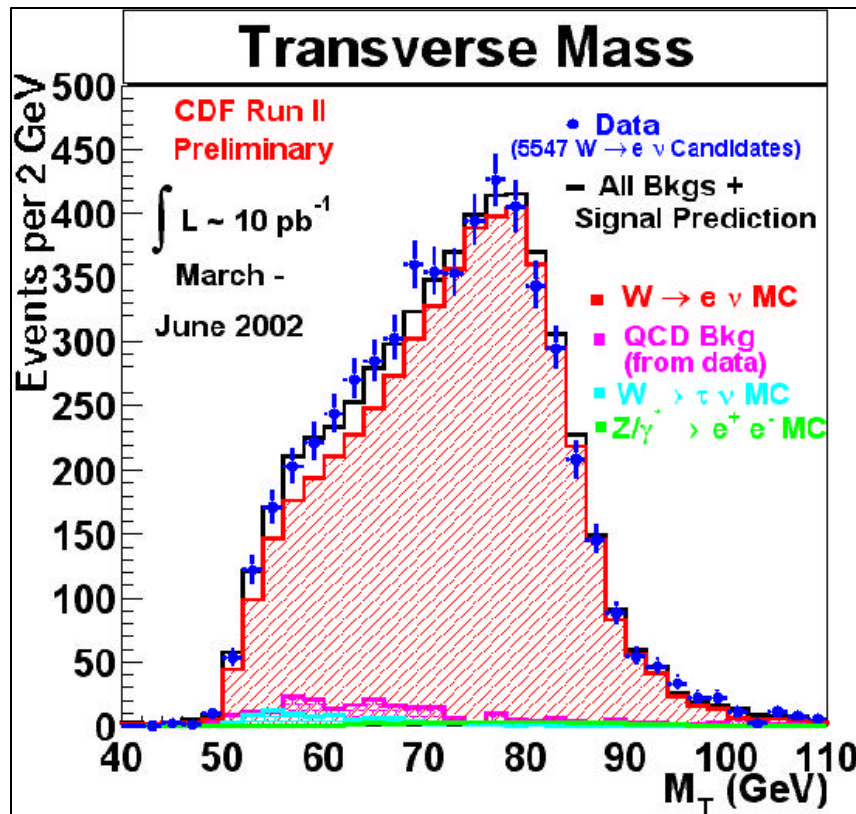
## W Event Selection

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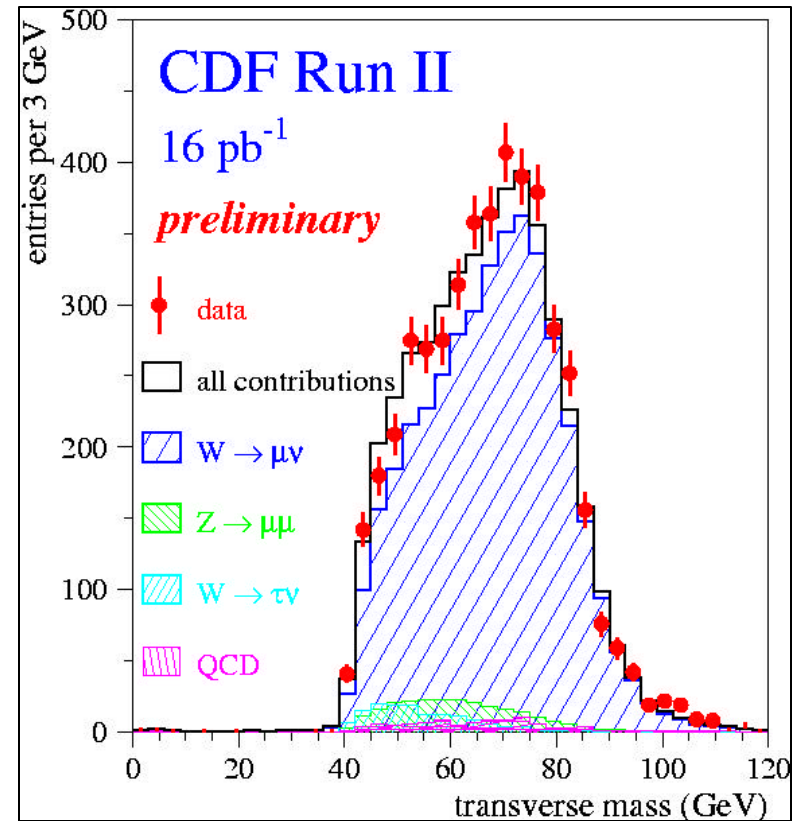
$W \rightarrow e \nu$	$W \rightarrow \mu \nu$
$ \eta^e  < 1.0$	$ \eta^\mu  < 0.6$
$E_T^e > 25 \text{ GeV}$	$P_T^\mu > 20 \text{ GeV}$
$E_T^\nu > 25 \text{ GeV}$	$E_T^\nu > 20 \text{ GeV}$
$E_T^{\text{ISO}} < 4 \text{ GeV}$	$E_T^{\text{ISO}} < 2 \text{ GeV}$



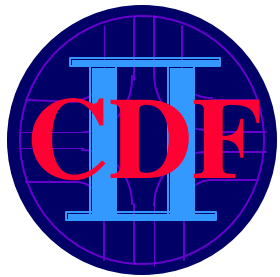
# $M_T$ Distributions



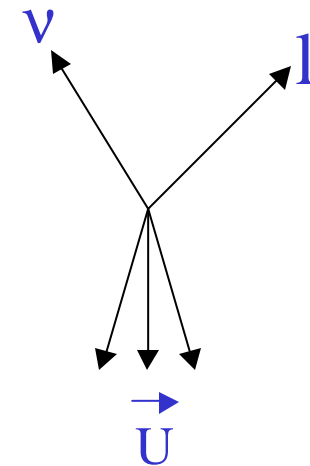
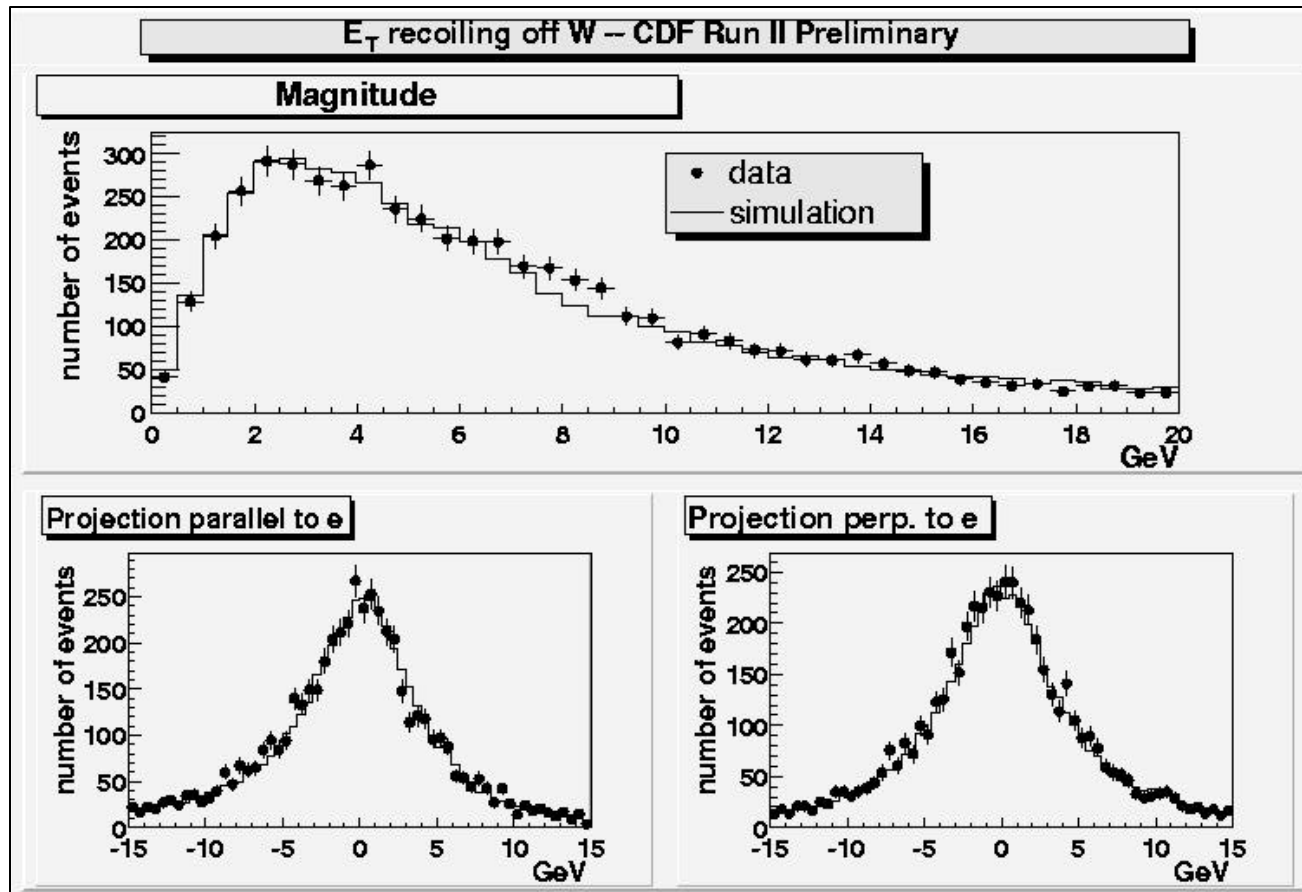
$W \rightarrow e \nu$  (5547 events)

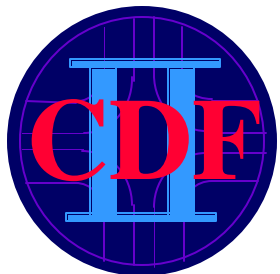


$W \rightarrow \mu \nu$  (4561 events)

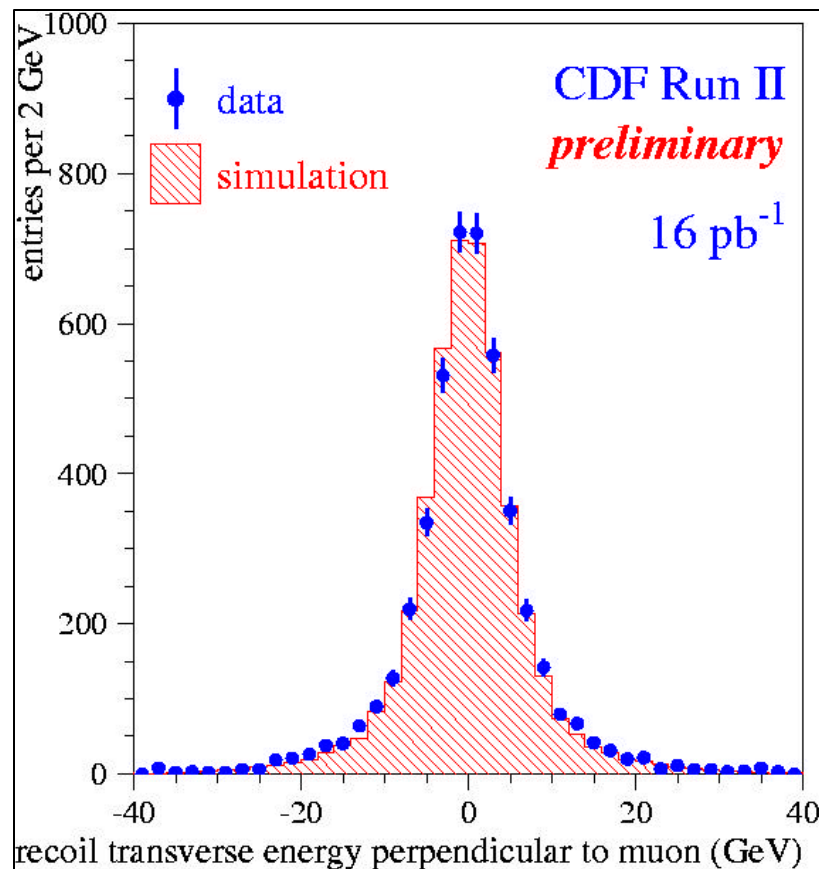
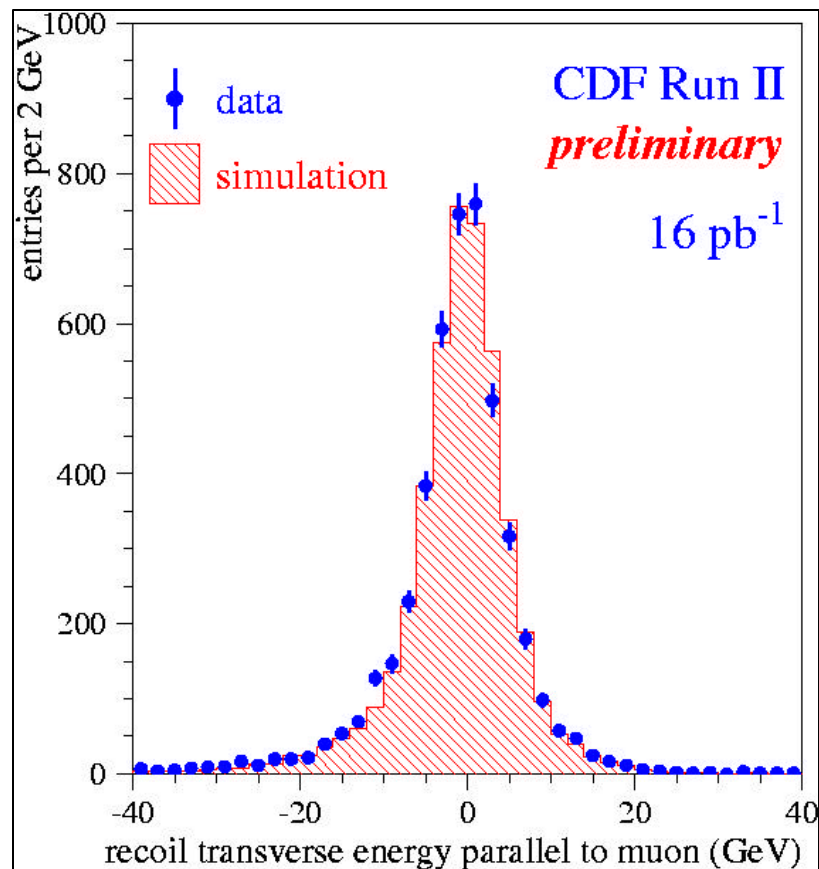


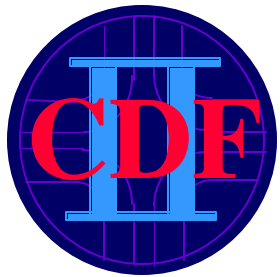
# Recoil Energy (Electron Channel)



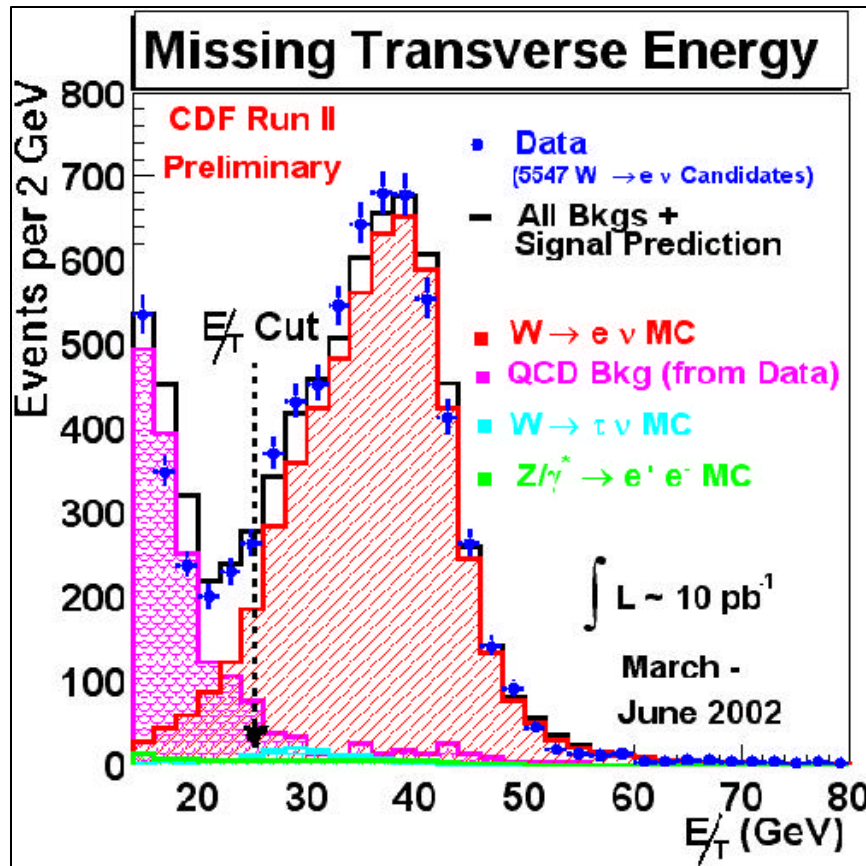


# Recoil Energy (Muon Channel)

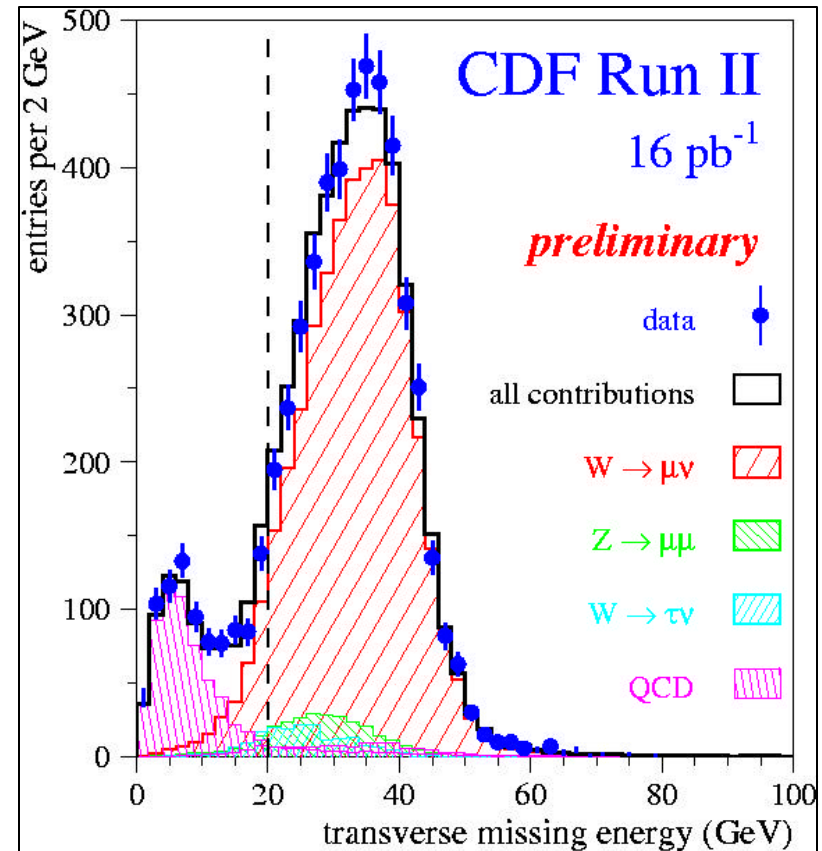




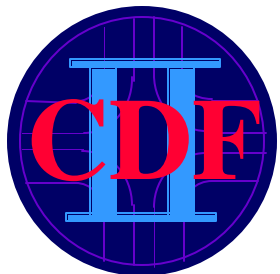
# Missing $E_T$ Distributions



$W \rightarrow e \nu$



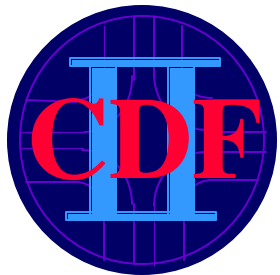
$W \rightarrow \mu \nu$



## Cross Section Input Parameters

	$W \rightarrow e \nu$	$W \rightarrow \mu \nu$
$N_{\text{obs}}$	5547	4561
$N_{\text{bg}}$	$409 \pm 85$	$569 \pm 63$
$A (\%)$	$23.4 \pm 0.9$	$14.2 \pm 0.4$
$\epsilon (\%)$	$81.1 \pm 1.8$	$63.2 \pm 3.8$
$\int \mathcal{L} \cdot dt \text{ (pb}^{-1}\text{)}$	$10.4 \pm 1.0$	$16.5 \pm 1.6$

CDF Run II Preliminary

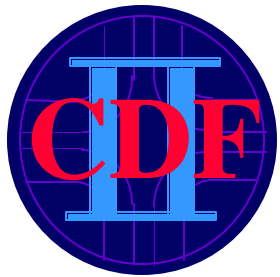


# Run II W Cross Sections

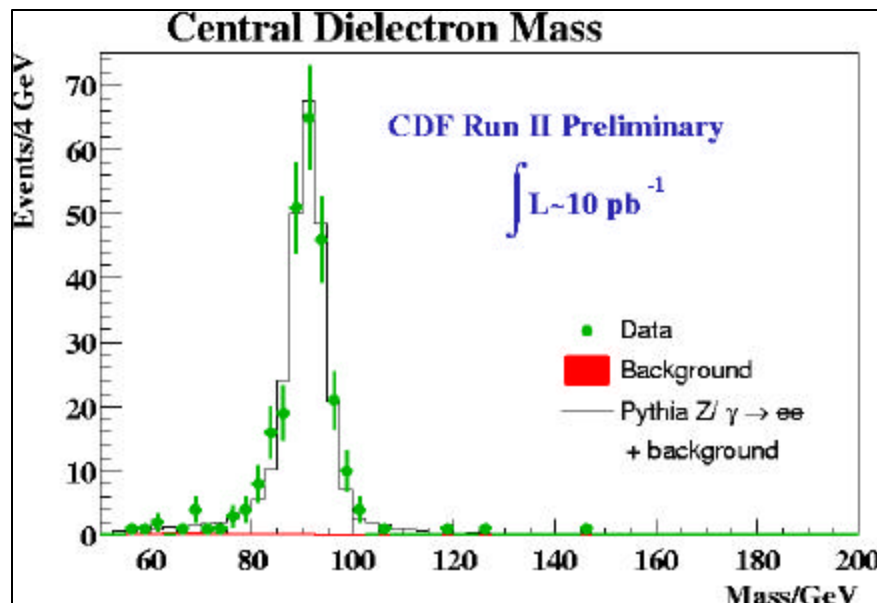
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CDF Run II Preliminary

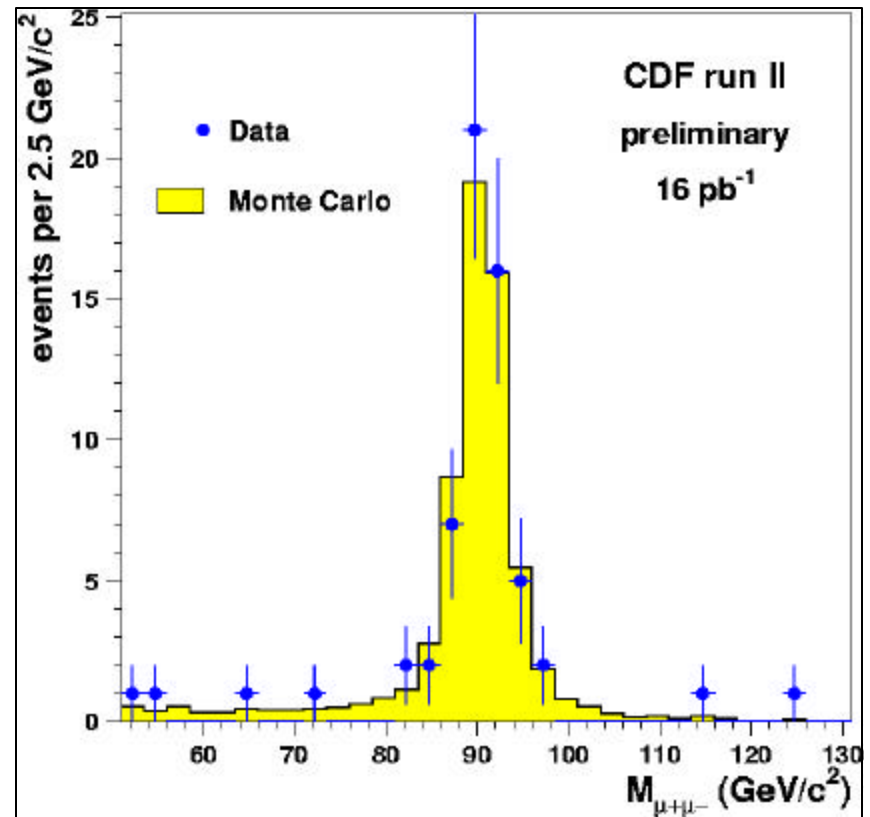
- $\sigma \cdot B (W \rightarrow e\nu) =$   
 $2.60 \pm 0.03 \text{ (stat)} \pm 0.13 \text{ (sys)} \pm 0.26 \text{ (lum)} \text{ nb}$
- $\sigma \cdot B (W \rightarrow \mu\nu) =$   
 $2.70 \pm 0.04 \text{ (stat)} \pm 0.19 \text{ (sys)} \pm 0.27 \text{ (lum)} \text{ nb}$
- CDF Run I ( $W \rightarrow e\nu$ ) :  
 $\sigma \cdot B = 2.49 \pm 0.12 \text{ nb } (\sqrt{s} = 1.8 \text{ TeV})$
- NNLO Theory (W. Stirling) :  
 $\sigma \cdot B = 2.50 \text{ nb } (\sqrt{s} = 1.8 \text{ TeV})$   
 $\sigma \cdot B = 2.73 \text{ nb } (\sqrt{s} = 1.96 \text{ TeV})$



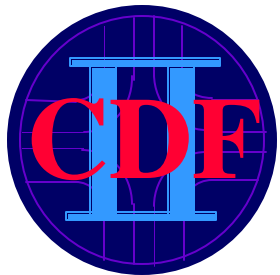
# Reconstructed Z Boson Signals



$Z \rightarrow ee$



$Z \rightarrow \mu\mu$



## $R_\mu$ Measurement

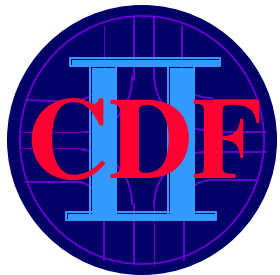
$$R_\mu = \frac{\sigma(p\bar{p} \rightarrow W) \Gamma(W \rightarrow \mu\nu) \Gamma(Z)}{\sigma(p\bar{p} \rightarrow Z) \Gamma(Z \rightarrow \mu\mu) \Gamma(W)} = \frac{N_W \epsilon_Z A_Z}{N_Z \epsilon_W A_W}$$

$N_W$	$3992 \pm 93$
$N_Z$	$53.2 \pm 8.0$
$\epsilon_Z / \epsilon_W$	$0.884 \pm 0.053$
$A_Z / A_W$	$0.2060 \pm 0.0048$

$$R_\mu = 13.66 \pm 1.94 \text{ (stat)} \pm 1.16 \text{ (sys)}$$

$$\Gamma_W = 1.67 \pm 0.24 \text{ (stat)} \pm 0.14 \text{ (sys)} \\ \pm 0.01 \text{ (theory)}$$

CDF Run II Preliminary



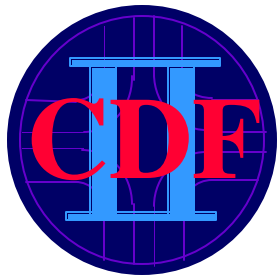
## Future Prospects

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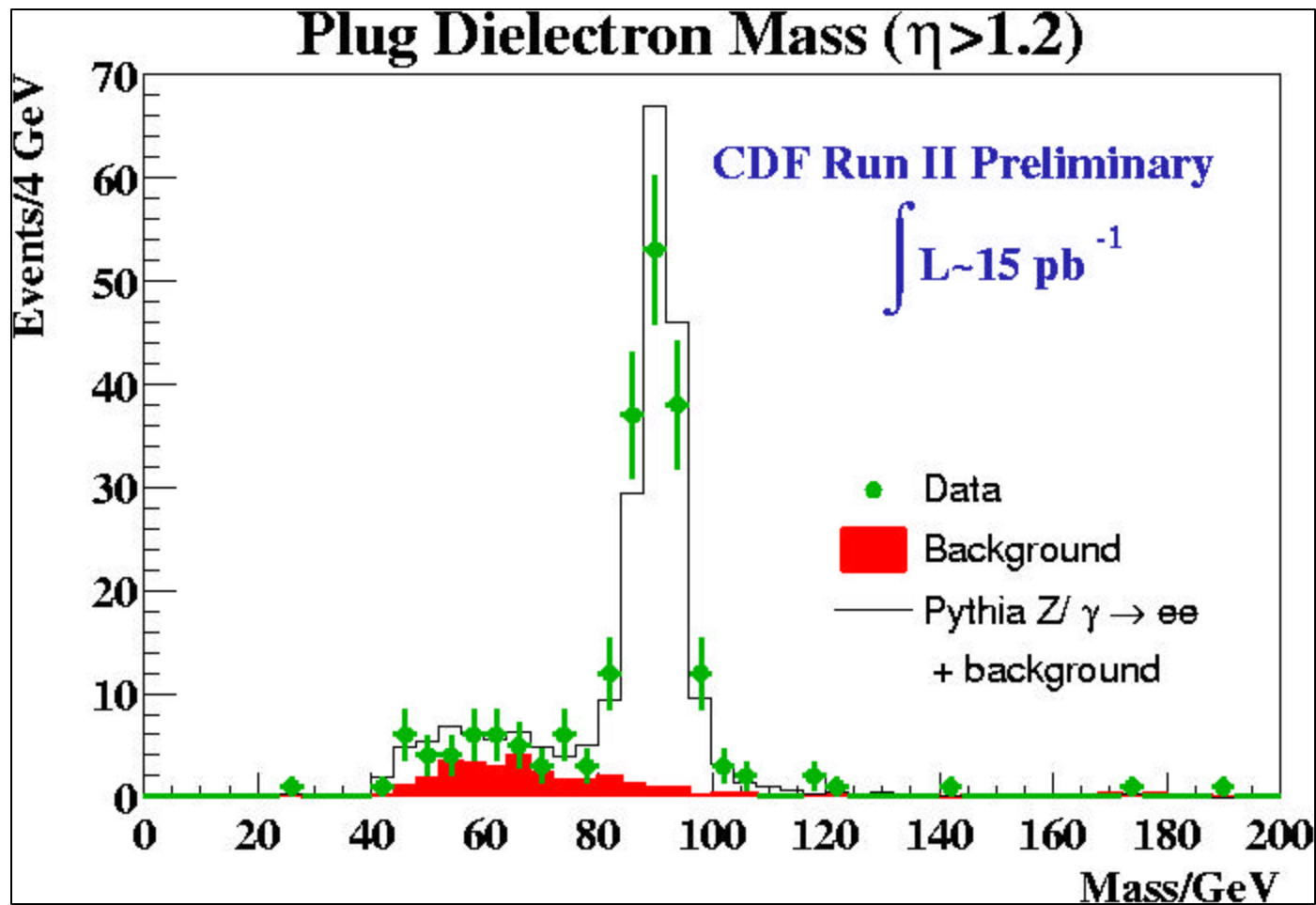
- Run IIA is defined as  $2 \text{ fb}^{-1}$  collected during a 2-3 year period.
- CDF detector upgrades provide increased acceptance for leptons out to  $|\eta| < 2$ .
- The rise in  $\sqrt{s}$  from 1.8 TeV to 1.96 TeV increases the W and Z cross sections  $\sim 10\%$ .

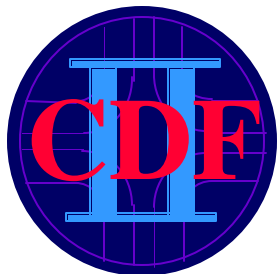
Sample	Run I	Run II
$W \rightarrow l\nu$	77K	2300K
$Z \rightarrow ll$	10K	202K

Estimated Event Yields

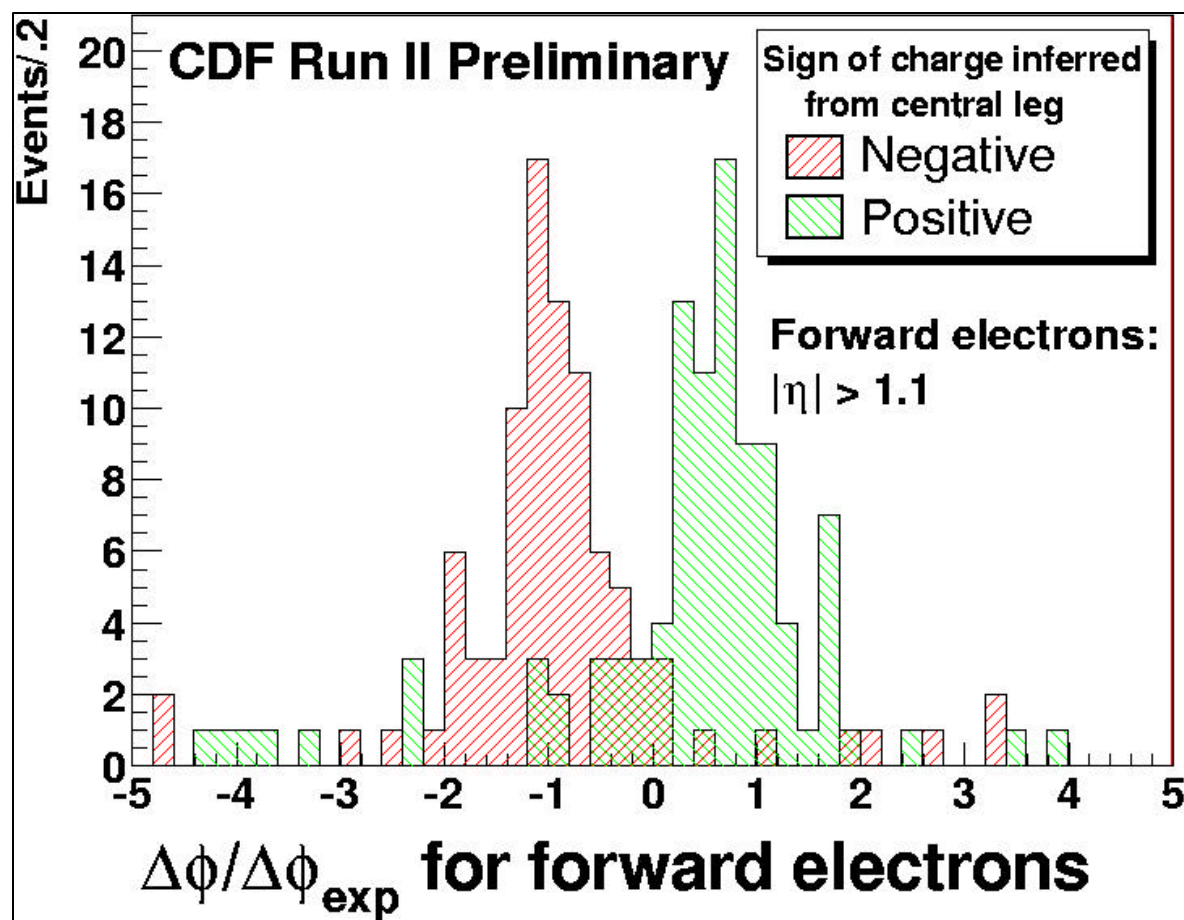


## Electrons in Plug





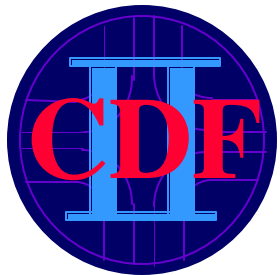
## Silicon Tracking at large $\eta$



$$\Delta\phi = \phi_s - \phi_o \propto 1/P_T$$

$$\Delta\phi_{\text{exp}} \propto 1/E_T$$

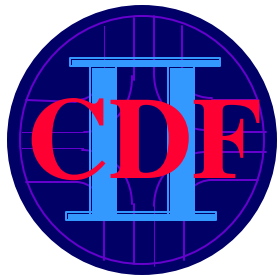
$$\Delta\phi / \Delta\phi_{\text{exp}} \propto E / P$$



## $M_W$ Measurement

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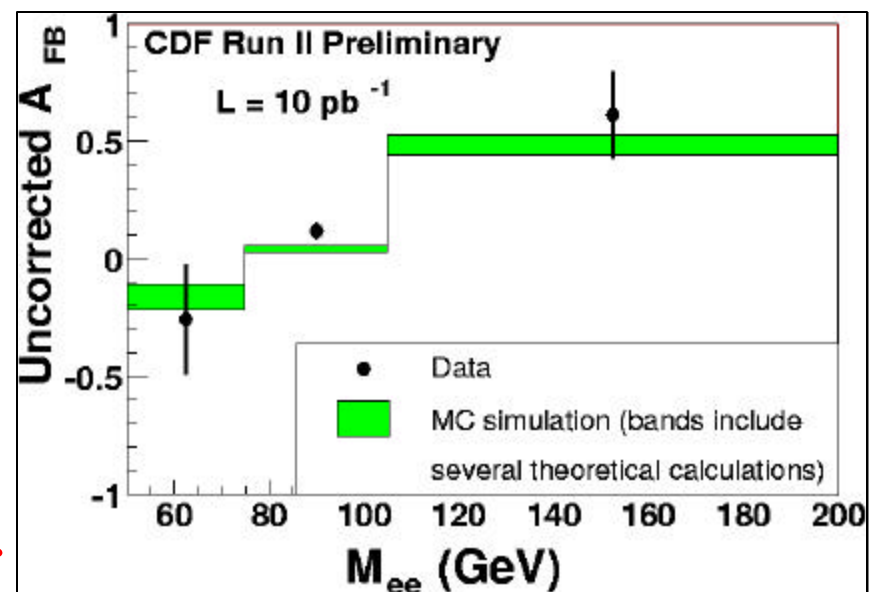
- $W$  mass is extracted from a fit to  $M_T^W$  since CDF does not measure  $p_z^\nu$ .
- Many of the systematic errors such as the scale & resolution of the lepton energy/momentum and the recoil model scale down with luminosity ( $Z \rightarrow l\bar{l}$ ).
- However,  $P_T^\nu$  resolution does depend on the average number of interactions per crossing.
- Based on Run I experience, expect  $\delta M_W = \pm 40$  MeV.



## Measurement of $A_{FB}$

- Direct probe of relative strengths of vector and axial couplings over corresponding  $Q^2$  range.
- Extract  $\sin^2\theta_W^{\text{eff}}$  from  $A_{FB}$  measured for lepton pairs in the vicinity of the z-pole.
- Search for non-SM heavy neutral gauge bosons using high mass pairs.

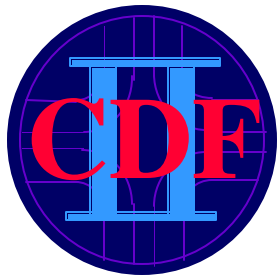
$$p\bar{p} \rightarrow Z/\gamma \rightarrow e^+e^-$$



$$A_{FB} = (N_F - N_B) / (N_F + N_B)$$

$$N_F = N_{\text{evt}} \text{ with } \cos(\theta^*) > 0$$

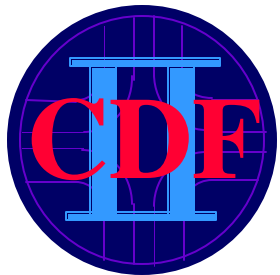
$$N_B = N_{\text{evt}} \text{ with } \cos(\theta^*) < 0$$



## Also

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- Study tri-linear couplings of  $W$ ,  $Z$ , and  $\gamma$  to test Standard Model and search for anomalous couplings (new physics).
- $W$  charge asymmetry measurements provide an important constraint on parton distribution functions. Increased lepton coverage at high  $\eta$  in Run II will allow these measurements to be extended into the most interesting range.



## Conclusions

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- With  $2 \text{ fb}^{-1}$  in Run II, CDF will have the opportunity to further constrain the values of important EWK Standard Model parameters.
- In conjunction with direct searches for the Higgs boson, these results will provide an increasingly stringent test of the Standard Model.
- Initial measurements of W and Z production cross sections indicate good understanding of detector .